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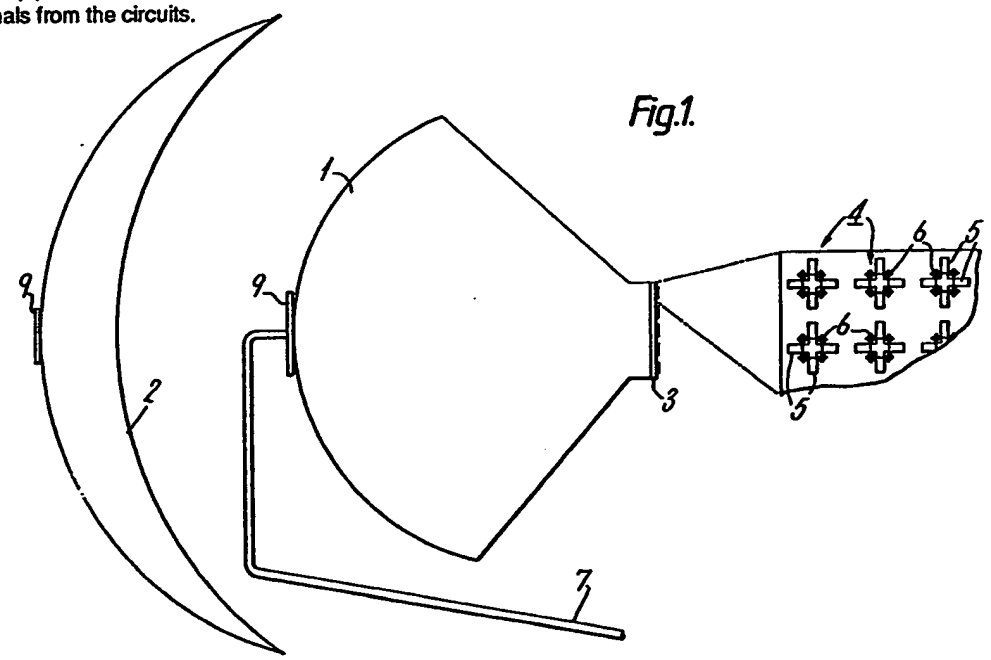
(54) Microwave millimetric array receivers

(57) The receiver comprises a dielecric lens 1 which directs received and local oscillator radiation onto an array of integrated antenna/mixer circuits 4 supported by a dielectric substrate 3. Each antenna/mixer circuit 4 may comprise a crossed dipole pair 5 interconnected by mixer diodes 6. A problem is the uniform illumination of the whole array, especially if it is a comparatively large one, with the local oscillator radiation. Also because the whole array is irradiated (swamped), the necessary local oscillator power may be unduly high. Herein, there is proposed the use of a steerable reflector dish or a contorollably - directional antenna array 9 which directs the local oscillator radiation *via* the lens onto specific circuits or specific array portions. The circuits are thus scanned with the local oscillator signal, say in synchronism with the scanning of the IF signals from the circuits.

Fig.1.



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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Fig.1.

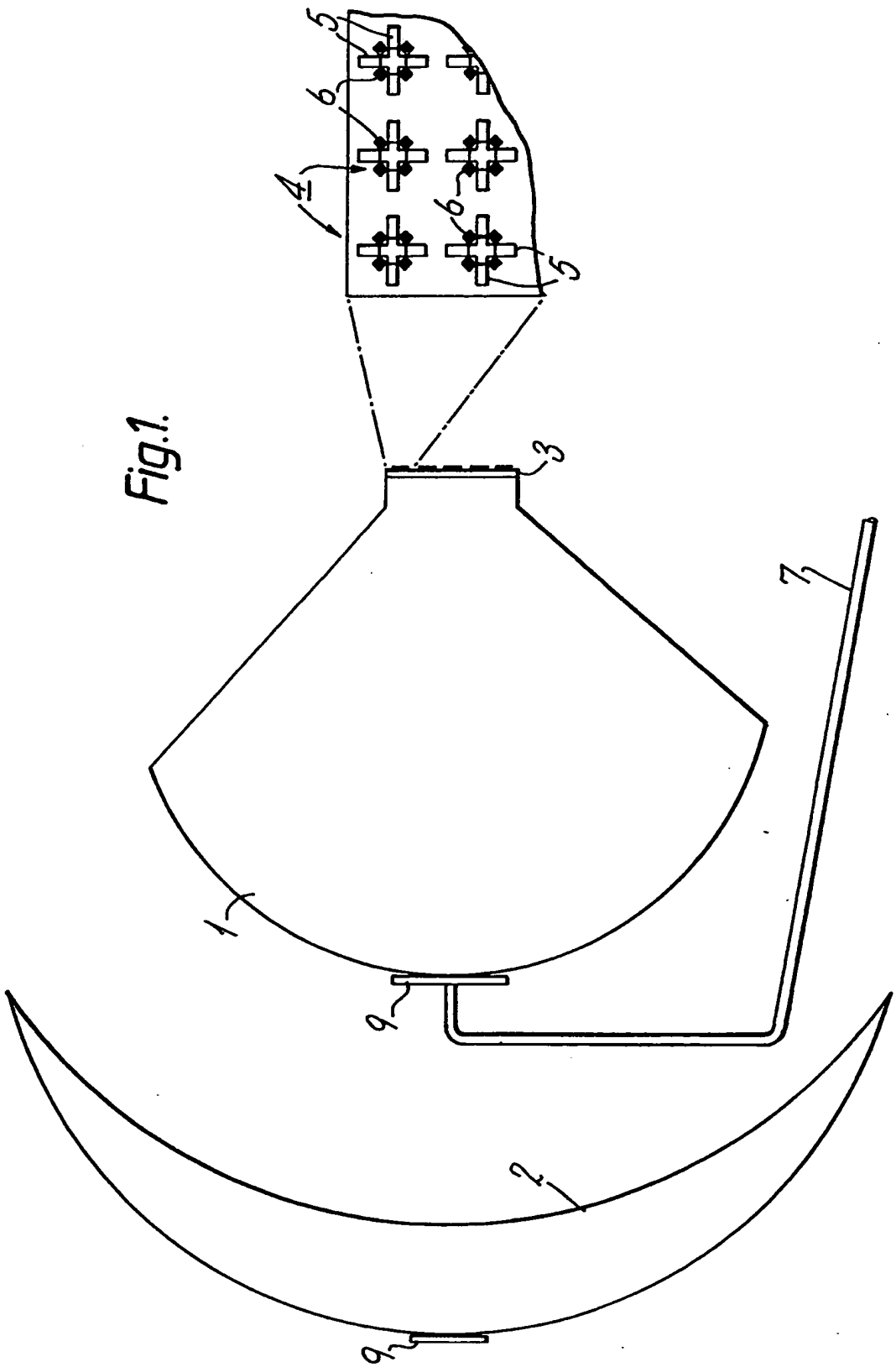


Fig.2.

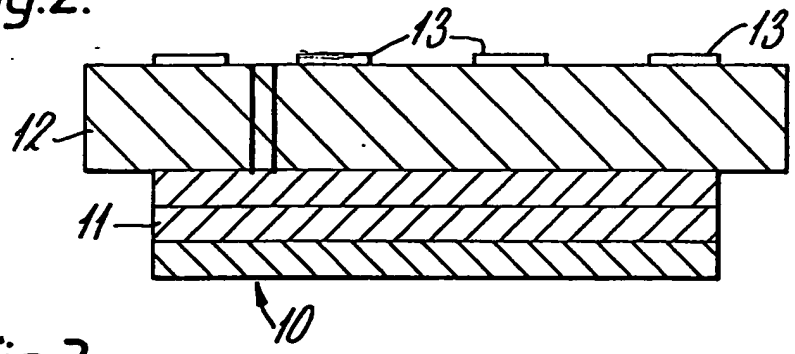


Fig.3.

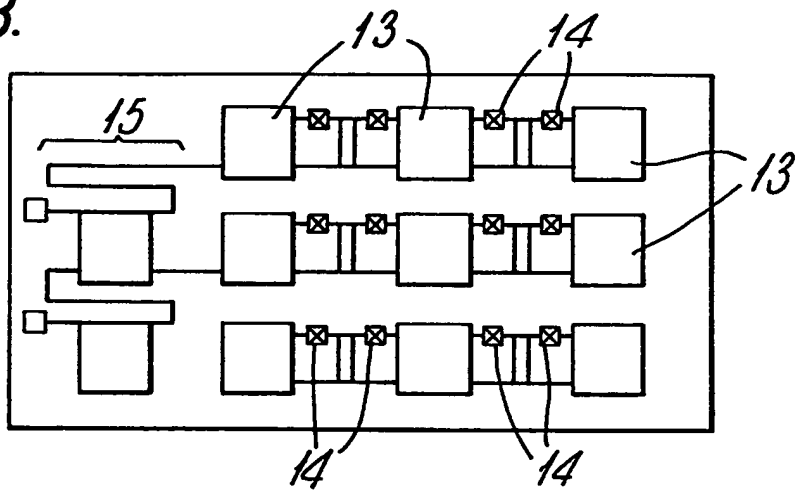


Fig.4.

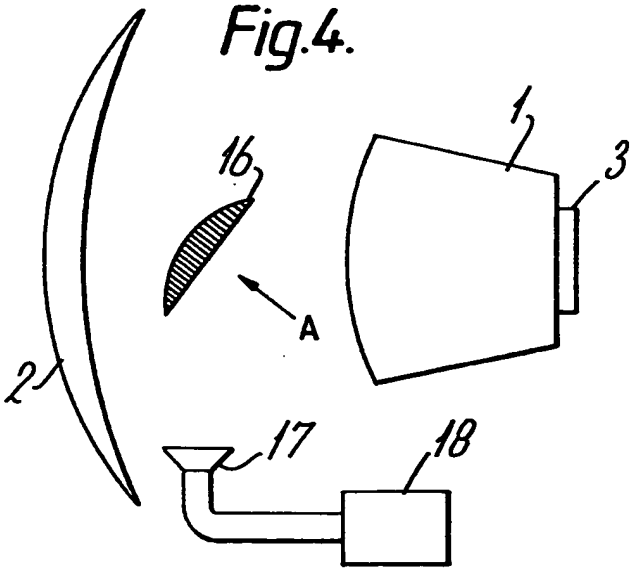


Fig.5.

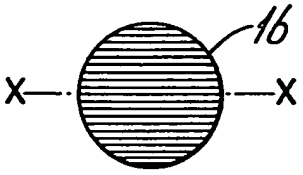


Fig.6.

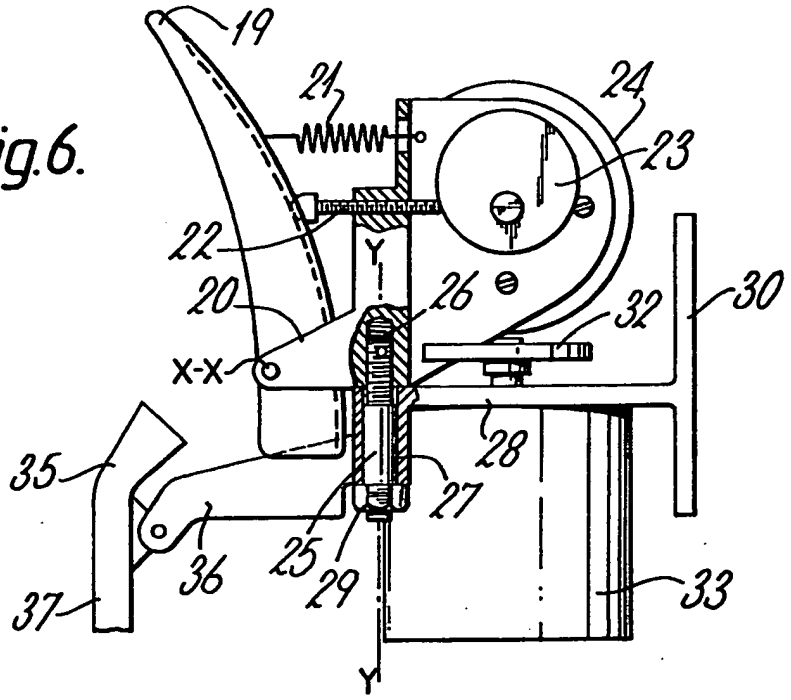

19
21
24
23
22
Y
20
26
32
30
X-X
28
35
27
25
29
36
37
33
Y

Fig.7.

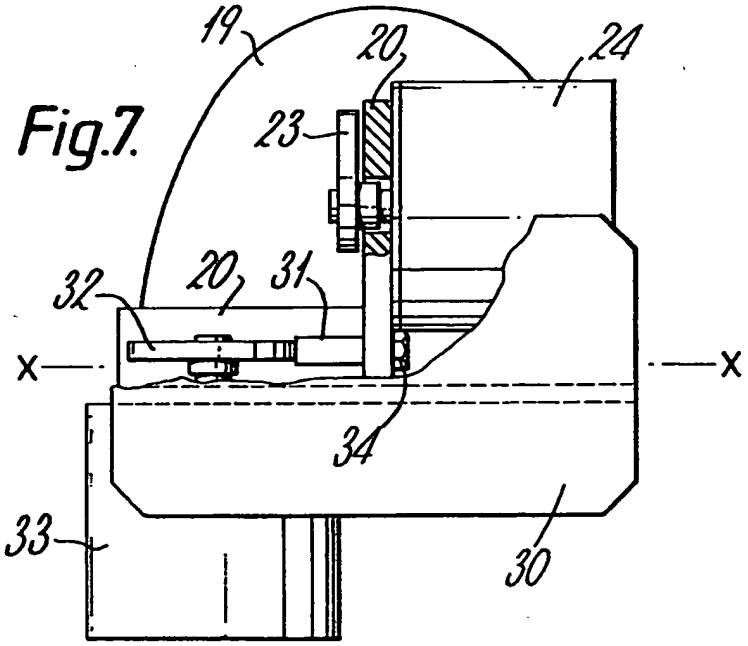
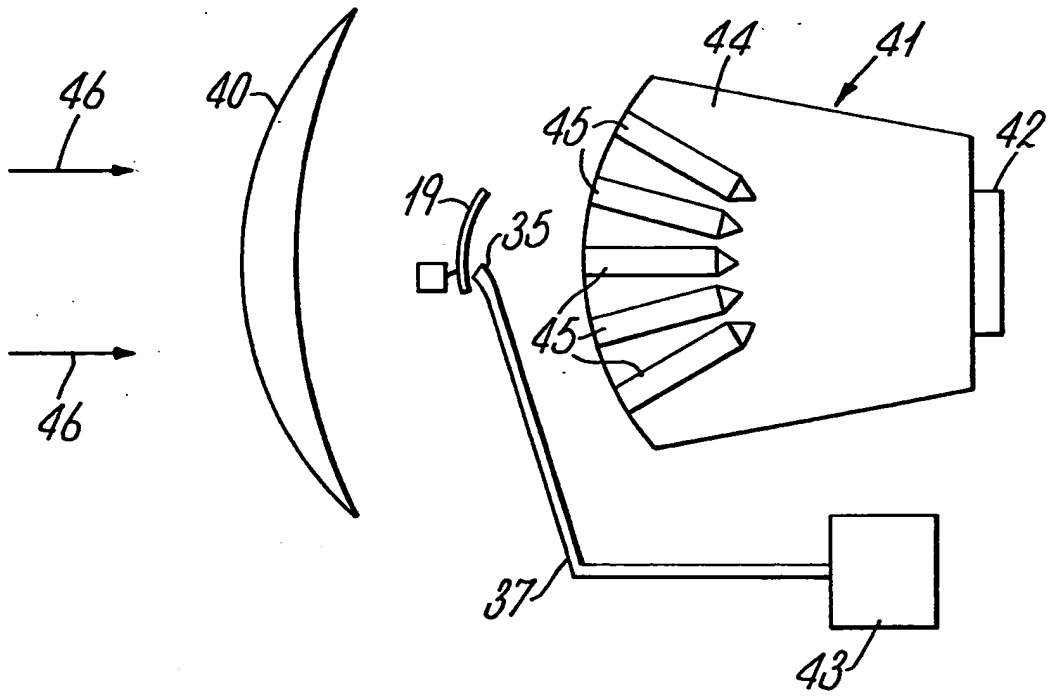

19
20
24
23
32
20
31
X
X
34
33
30

Fig.8.



MICROWAVE/MILLIMETRIC WAVEBAND ARRAY RECEIVERS

This invention relates to receivers for the microwave and millimetre wavebands and comprising a dielectric lens for receiving electromagnetic energy and, attached to the back face of the lens, a dielectric substrate carrying, on its face remote from the lens, an array of antenna/mixer circuits. Each antenna/mixer circuit comprises a pair of crossed dipoles or slots interconnected with each other and with an IF output circuit by way of diodes which, along with the components of the IF circuit, may be formed monolithically in the substrate. The two dipoles of each antenna/mixer respond respectively to the received radiation and to a local oscillator signal which is made available to the array, and these two signals are mixed to form an IF signal. Depending upon the direction of arrival of the received radiation at the dielectric lens, the radiation is focussed mainly onto a corresponding one of the array of antenna/mixers. Thus the receiver has a kind of image resolving capability. In effect, the overall field of view of the lens is divided into a series of areas corresponding to respective ones of the antenna/mixer circuits.

In order to pass the local oscillator signal to the array, the local oscillator is usually coupled to a radiating horn positioned near the front face of the dielectric lens, or at the side or rear of the lens in which case a polarisation sensitive reflector is incorporated in the lens so as to direct the local oscillator radiation onto the array. In general, the object is to flood the whole of the array with the local oscillator radiation. The problem with this known system is that it is sometimes difficult to achieve

uniform illumination of the antenna/mixer circuits. Also, if the number of antenna/mixer circuits in the array is comparatively large, quite a large amount of local oscillator power is needed.

According to the invention, there is provided a receiver comprising dielectric lens means, a dielectric substrate supporting an array of integrated planar antenna/mixer circuits, the substrate being positioned near the rear face of the dielectric lens for received radiation to be directed by the lens through the substrate to the array, and means for feeding local oscillator radiation to the array, said local oscillator radiation feeding means being operable for illuminating an area of the array plane which does not cover the whole of the array, and said local oscillator radiation feeding means being controllably directional so that said area can be positioned to include a selected antenna/mixer circuit.

Using the techniques described herein, there may be achieved a system wherein the local oscillator radiation is directed to individual antenna/mixer circuits or onto selected portions of the circuit array, this reducing the overall local oscillator power requirement.

For a better understanding of the invention, reference will now be made, by way of example, to the accompanying drawings, in which:-

Figure 1 is a diagrammatic view of a first receiver,

Figures 2 and 3 are a diagrammatic sectional front view and a diagrammatic plan view respectively of a patch antenna array used in the receiver of Figure 1,

Figure 4 is a diagrammatic view of a second receiver,

Figure 5 is a view in the direction A in Figure 4 of a reflector dish used in the Figure 4 receiver,

Figures 6 and 7 are an elevation and a side view respectively of a feed horn and a steerable reflector, and

Figure 8 is a diagrammatic sectional side-view of another receiver. The receiver of Figure 1 comprises a lens 1 made of a high dielectric constant material in front of which there is positioned a further lens 2 which is made of comparatively low dielectric constant material. At the rear face of the lens 1 there is fixed a dielectric substrate 3 carrying at its rear face a planar integrated array of antenna/mixers 4. Each antenna/mixer circuit comprises a pair of crossed dipoles 5 interconnected via diodes 6. In each case, one of the dipole pairs is responsive to linearly polarised radiation received via the lenses 1 and 2 while the other dipole pair is responsive to orthogonally polarised local oscillator radiation which it receives. The local oscillator radiation is fed via a waveguide 7 to a patch antenna array 8 mounted at the front of the lens 1 between the lenses 1 and 2. If the receiver is to form part of a radar system, a transmission antenna 9 may be provided say at the front of lens 2 as shown or elsewhere. The antenna array 8 is operable to illuminate only a portion of the array 5 but it is directional so that this portion can be moved as desired over the array to include a selected one of the antenna/mixer circuits. Figures 2 and 3 show the patch antenna array used in the Figure 1 receiver. It comprises a waveguide 10 containing a waveguide to coaxial transition device 11 which converts the signal to a form

suitable for microstrip circuitry. Attached to the waveguide is a substrate 12 carrying an array of antenna patches 13 linked as shown via varactor phase-shifters 14 and to a microstrip signal-forming circuit 15. Using d.c. control signals fed to the array, power can be distributed to different patches on the antenna array and the integral phase shifter elements allow the beam to be steered as desired.

The high-dielectric constant of the lens 1 results in most of the power produced by the antenna array 8 being radiated into the lens 1 and hence onto the array 4. By controlling the varactor phase-changers 14 via circuit 15 so as to vary the phase at the different patches 13, the R.F. beam produced by the array can be scanned over the array 4, only a portion of the array being illuminated at any one time. If the receiver constitutes part of a radar target-seeker, a potential target might occupy say a portion of array 4 containing 5 x 5 of the antenna/mixer circuits. The target can be detected and its position within the whole array can be found by scanning the local oscillator beam over the array and then, having found the target, the scanning can cease. The beam is then steered so as to track the target movement, ie the beam is steered in accordance with the relative movement of the target so as to illuminate the 5 x 5 circuit portion of the array 4 which contains the target.

Instead of using phase-changing elements, beam steering can be achieved by the local oscillator power being switched between different ones of the antenna patches, or the respective power levels at different ones of the patches being varied, using for example a series of p-i-n diodes and a hybrid type of control system.

In any case, the microstrip circuitry could be replaced by another suitable form, for example by a fin-line circuit. Also, the square patch antenna array could be replaced say by a dipole array or by a Dubost antenna.

In the receiver of Figures 4 and 5 a low dielectric constant lens 2 is positioned in front of a high dielectric constant lens 1 and a substrate 3 carrying an antenna/mixer array (not shown) is positioned at the back of the lens 1 as before. A steerable gridded wire reflector dish 16 is positioned as shown between the lenses 1 and 2 to receive radiation from a horn 17 coupled to the local oscillator 18. The dish reflector has the property of reflecting the linearly polarised local oscillator radiation while transmitting the orthogonally polarised received radiation. By steering the dish 16, for example by turning it about axes X-X in Figure 5, the local oscillator radiation can be directed onto a specific area of the array of antenna/mixer circuits on the back of substrate 3.

The gridded dish 16 of figures 4 and 5 can be replaced by a solid antenna dish and steering assembly provided this is sufficiently small so as to not appreciably mask the aperture of lens 1. A receiver comprising a solid antenna dish is shown in figure 8 while figures 6 and 7 show a suitable solid dish and steering assembly. This assembly comprises a reflector dish 19 pivotably mounted to a support member 20 for turning about axis X-X. A tension spring 21 is coupled between the dish and the support member so as to maintain the dish pulled back against a push-rod 22 which, in turn, bears against a cam 23 driven by a stepper motor 24 fixed to the member 20.

The motor 24 turns the cam 23 and correspondingly moves the dish about axis X-X. One end of a spigot 25, which is screw-threaded at each end but not in the middle, is screwed into a correspondingly threaded hole 26 in the member 20. The central unthreaded portion of spigot 25 lies in a bearing 27 formed in a support structure 28 so that the member 20 along with the dish 19 can turn about the axis YY of the spigot. The spigot is held in position within the bearing 27 by a nut 29 screwed onto its other end. The support structure 28 includes a fixing flange 30 by which the whole assembly can be fixed in position between the low and high dielectric constant lenses of the receiver say at about the position occupied by the antenna array 8 in figure 1. A threaded push-rod 31 is screwed into a hole in member 20 and engages a cam 32 mounted on the output shaft of a stepping motor 33 fixed to the structure 28. Rotation of motor 33 thus moves the antenna dish about axis Y-Y. The push-rod 31 can be screwed into or out of its engaging threaded hole in member 20 and secured in position by a lock nut 34 to permit the initial position of the antenna to be set. The antenna dish receives radiation from a feed horn 35 supported by an appropriately shaped extension 36 of structure 28 and coupled via a waveguide 37, to a local oscillator (not shown). The radiator from horn 35 is formed into a beam by reflector dish 19, which beam is steered by appropriately controlling motors 24 and 33 so as to be incident on a chosen portion of the antenna/mixer circuit array as in the previous embodiments.

The receiver of figure 8 comprises a low dielectric constant lens 40 and a high dielectric constant lens 41 at the rear or output

face of which there is a substrate 42 carrying, at its rear face, an array of integrated antenna/mixer circuits (not shown) as before.

The local oscillator radiation is supplied by a suitable generator 43 coupled *via* waveguide 37 and feed horn 35 of a dish/steering assembly like that described with reference to figures 6 and 7.

The lens 41 comprises a member 44 generally made of material having a first dielectric constant E_r (having a value of twelve perhaps) which, although it is high in relation to that of the lens 40, is relatively low in relation to the dielectric constant of each of a series of elongate elements 45, preferably of circular cross-section, inserted or otherwise provided within the member 44. Each of these elements night be made of material having a dielectric constant of say forty. For example, they could be made of Barium Nanotitanate (E_r = 40) or Zironium Titania Stannate (ZTS) (E_r = 38). They extend from the front face of lens 41 to between a third and a half way through it, their inner ends being closer together than their outer ends, *ie* the ends at the front face of the lens. Only some of the elements 45 can be seen in the figure, some being behind the ones shown. If the front face of the lens 41 were drawn, it would comprise say a circle delineating the shape of the member 44 and, within that circle, a two-dimensional array of say circles delineating the outer ends of respective ones of the elements 45. In any case, the figure is only diagrammatic - thus, for example, there could be quite a large number of elements 45 many more than is suggested by the figure.

The shape, length, number and positions of the elements 45 are chosen to facilitate the transfer of the local oscillator power to the antenna/mixer circuits. Each element forms in effect an individual radiating element set within the lens 41.

The cross-sectional area of the elements 45 is small compared with that of the lens 41 as a whole so they do not have any undue effect on the signal radiation 46 received by the lens. The local oscillator radiation however, because it is directed onto specific elements 45 by the steered dish 19, is funnelled towards a chosen specific antenna/mixer circuit (or at least onto a specific area of the overall array of circuits).

It will be realised that a lens with inserts as shown in figure 8 could also be used in the receivers of figures 1 and 4.

CLAIMS

1. A receiver comprising dielectric lens means, a dielectric substrate supporting an array of integrated planar antenna/mixer circuits, the substrate being positioned near the rear face of the lens through the substrate to the array, and means for feeding local oscillator radiation to the array, said local oscillator radiation feeding means being operable for illuminating an area of the array plane which does not cover the whole of the array, and said local oscillator radiation feeding means being controllably directional so that said area can be positioned to include a selected antenna/mixer circuit.

2. A receiver substantially as hereinbefore described with reference to the accompanying drawings.

Amendments to the claims have been filed as follows

CLAIMS

1. A receiver comprising dielectric lens means, a dielectric substrate supporting an array of integrated planar antenna/mixer circuits, the substrate being positioned near the rear face of the lens for received radiation to be directed by the lens through the substrate to the array, and means for feeding local oscillator radiation to the array, said local oscillator radiation feeding means being operable for illuminating an area of the array plane which does not cover the whole of the array, and said local oscillator radiation feeding means being controllably directional so that said area can be positioned to include a selected antenna/mixer circuit.

2. A receiver according to Claim 1, wherein said local oscillator radiation feeding means comprises a fixed array of antenna elements and control means for controlling local oscillator radiation components radiated by the respective antenna elements to produce, in combination, a steerable directional radiation beam.

3. A receiver according to Claim 1, wherein said local oscillator radiation feeding means comprises a movably mounted radiation reflector and actuator means for producing a directional local oscillator radiation beam coupled to the reflector for moving the reflector to steer said beam.

4. A receiver according to Claims 1, 2 or 3, wherein said dielectric lens means comprises a forward and a rearward lens component spaced apart one from another and said local oscillator radiation feeding means is positioned between the two components and is operable to inject the local oscillator radiation into the rearward lens component via the front face of that component.

5. A receiver substantially as hereinbefore described with reference to the accompanying drawings.

EXAMINER'S REPORT TO THE COMPTROLLER
UNDER SECTION 17(5)
(The Search Report)

8611029

FIELD OF SEARCH: The search has been conducted through the relevant published UK patent specifications and applications, and applications published under the European Patent Convention and the Patent Co-operation Treaty (and such other documents as may be mentioned below) in the following subject-matter areas:-

UK Classification H1Q (QFC - FJ; QFL - FX)

(Collections other than UK, EP & PCT:) Selected US specifications in H01Q 3/00; 3/12 - 20; 3/24 - 46 & 23/00

DOCUMENTS IDENTIFIED BY THE EXAMINER (NB In accordance with Section 17(5), the list of documents below may include only those considered by the examiner to be the most relevant of those lying within the field (and extent) of search)

Category	Identity of document and relevant passages	Relevant to claim(s)
	NONE	

CATEGORY OF CITED DOCUMENTS

X relevant if taken alone
Y relevant if combined with another cited document
P document published on or after the declared priority date but before the filing date of the present application
E patent document published on or after, but with priority date earlier than, the filing date of the present application

Search examiner P HAYWARD

Date of search 22.10.86

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